IN THE DRAWINGS:

Submitted herewith are replacement sheets of drawing for Figs. 1, 2, 10, 11 and 12, in which Figs. 1-2 have been corrected to add reference numeral 1 and Fig. 10 has been corrected to add reference numeral 2 to denote the two embodiments of ion beam apparatus, and in which Figs. 11-12 have been corrected to add the legend "prior art", thereby conforming the drawings to the written description in the specification.

REMARKS

In the last Office Action, claims 1, 2, 8 and 9 were rejected under 35 U.S.C. §102(b) as being anticipated by US 5,574,280 to Fujii et al. ("Fujii"), and claims 13-14 were rejected under 35 U.S.C. §102(a) as being anticipated by US 2002/0005492 to Hashikawa et al. ("Hashikawa"). Figs. 11-12 were objected to as not containing the legend "prior art" and appropriate correction was required.

In accordance with this response, the original claims have been replaced by new claims 15-29. The specification has been revised in editorial respects to correct informalities and improve the wording and to provide a direct antecedent basis for the claim language. Figs. 1, 2 and 10-12 have been corrected to conform to the written description in the specification, and replacement sheets of drawing incorporating the corrections have been submitted. As required by the Examiner, Figs. 11-12 have been amended to include the "prior art" legend.

The present invention relates to an apparatus and method for processing a sample using a focused ion beam to form a cross section in a portion of the sample and then using a gaseous ion beam to remove a fracture layer from the cross section in such a manner as to prevent re-attachment of the removed fracture.

During semiconductor wafer fabrication, it is often necessary to examine a sample for defects. For this purpose, an ion beam apparatus is typically used to process a sample for observation. This is done by using a focused ion beam of, for example, gallium ions to form an observation cross section in a sample, after which the cross section is observed using an electron beam radiation unit.

During processing of the sample to form the cross section, gallium ions from the focused ion beam are injected into the cross section of the sample and form a damage layer known as a fracture layer. The presence of the fracture layer adversely affects high-powered TEM observation and presents a disadvantage in that a normal crystal lattice image of the cross section on an atomic level cannot be obtained. The present invention addresses this problem in a novel manner and effects removal of the fracture layer without re-attachment of the fracture, i.e., gallium ions, to the observation cross section.

In the embodiment shown in Figs. 1-2, the ion beam apparatus comprises a holder member 11 that holds a sample 3 by holding an end of the sample. In this embodiment, as shown in Figs. 4-6, the bottom end of the sample is attached to a mounting recess 27 of a holding part 24 of the holder member 11. A focused ion beam unit 12 irradiates a focused ion beam onto the sample from above and approximately orthogonally to a

top surface of the sample held by the holder member 11 to form an observation cross section 4 in a portion of the sample 3 accompanied by formation of a fracture layer on the cross section. A removing beam unit 13 irradiates a gaseous ion beam onto the cross section 4 of the sample 3 held by the holder member 11 and removes the fracture layer from the cross section.

In this embodiment, the gaseous ion beam is irradiated from the held end side of the sample (see Fig. 7(b)) so that its irradiating direction is tilted with respect to a normal to the cross section. In this manner, as shown in Fig. 9, the particles of the fracture layer that are removed from the cross section 4 and from sides of the sample 3 adjacent to the cross section 4 travel in directions away from the cross section so that the fracture particles do not re-attach to the cross section. In other words, the gaseous ion beam is not irradiated on the step portion of the sample 3 between the cross section and the remainder of the sample, which would undesirably result in re-attachment of the fracture particles to the cross section. During removal of the fracture layer by the gaseous ion beam, the sample 3 may be rotated in the directions b_1, b_2 to remove streaks from the cross section 4.

Independent claim 15 is directed to an ion beam apparatus comprising a holder member that holds a sample by

holding an end of the sample, a focused ion beam unit that forms a cross section in a portion of the sample by irradiating a focused ion beam onto the sample from above and approximately orthogonally to a top surface of the sample held by the holder member, and a removing beam unit that irradiates a gaseous ion beam onto the cross section of the sample held by the holder member and removes a fracture layer from the cross section, the gaseous ion beam being irradiated from the held end side of the sample so that its irradiating direction is tilted with respect to a normal to the cross section.

Independent claim 20 is directed to a ion beam apparatus comprising a holder member that holds a sample by holding an end of the sample, a focused ion beam unit that forms a cross section in a portion of the sample by irradiating a focused ion beam onto the sample from vertically above the sample held by the holder member, and a removing beam unit that irradiates a gaseous ion beam onto the cross section of the sample held by the holder member and removes a fracture layer from the cross section, the removing beam unit being disposed so that the gaseous ion beam is irradiated from a lower slanting direction with respect to the held sample by the holder member.

Independent claim 23 relates to an ion beam processing method and comprises a first step of holding a sample to be processed by holding the sample at an end

thereof, a second step of irradiating a focused ion beam onto the held sample from above to form a cross section in a portion of the sample, and a third step of irradiating a gaseous ion beam onto the cross section of the sample and removing a fracture layer from the cross section, the gaseous ion beam being irradiated from the held end side of the sample so that its irradiating direction is tilted with respect to a normal to the cross section of the sample.

No similar apparatus and method are disclosed or suggested by the prior art.

Fujii discloses an ion beam apparatus and method similar to the prior art described in the background of the present specification. As shown, for example, in the Fig. 1 embodiment, Fujii discloses an ion beam apparatus having a focused ion beam unit that irradiates a focused ion beam, for example, a gallium ion beam, onto a surface of a sample 5 to etch a predetermined area on a sample accompanied by doping of the gallium ions into the sample surface. A gas ion beam irradiation unit 3 irradiates a gaseous ion beam, such as an argon ion beam, onto the predetermined etched area of the sample 5 to remove the doped gallium ions by sputtering. In the Fig. 1 embodiment, the gallium ions that are removed by sputtering restick on the surface of the sample 5 and are removed by a wet cleaning and an etching process (column 4, lines 57-63). Other embodiments are shown in Figs. 2-4.

Fig. 6A-6F are explanatory diagrams illustrating the operations of the embodiments shown in Figs. 1-4. In the several embodiments disclosed by Fujii, various measures are taken to remove the fracture or contaminating particles that re-attach to the predetermined etched area of the sample. By contrast, in the present invention, measures are taken to reduce the extent of re-attachment of the fracture particles on the observation cross section.

One of the objects of the present invention is to overcome the problems inherent in the Fujii ion beam apparatus. As described in the present specification on page 4 and shown in Fig. 11, which the depicts the operation of a conventional ion beam apparatus of the type disclosed by Fujii, when an argon ion beam is irradiated onto a cross section 104 of a sample 103, the argon ion beam necessarily irradiates areas adjacent to the cross section 104. More particularly, the argon ion beam is irradiated onto a step part and other areas of the sample 103, and the irradiation onto the step part causes fracture particles of the fracture layer to be ejected and re-attached onto the cross section 104, thereby contaminating the cross section. Fujii recognizes this problem and takes measures to remove the re-attached fracture or contaminating particles. Unlike the present invention, Fujii does not reduce the re-attachment of the removed fracture particles.

With reference to the claims, Fujii does not disclose irradiating a gaseous ion beam from the gas ion beam irradiation unit 3 from the held end side of the sample but conversely shows irradiating the gaseous ion beam from the top end side of the sample, as shown in Figs. 6A-6F. Similarly, Fujii does not disclose irradiating the gaseous ion beam from a lower slanting direction with respect to the held sample as required by independent claim 20. Likewise, Fujii does not disclose the third step of independent claim 23, which requires that the gaseous ion beam be irradiated from the held end side of the sample.

Hashikawa has been cited for its disclosure of a holder member, and the reference does not teach or suggest the ion beam apparatus and method recited in new claims 15-29.

In view of the foregoing, the application is now believed to be in allowable form. Accordingly, favorable reconsideration and passage of the application to issue are respectfully requested.

Respectfully submitted,

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March 28, 2007
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